[illegible]

l-Shorouk Academy The Higher Institute of Engineering
Department of Electronics and Communications
Third year Communications | Systems and Networks

Sheet four
Network Realization

[1] (i)Find the transmission (T) matrix for the circuit shown in figure (1)
(ii) Show that that circuit realizes **a gyrator** and
(iii) Find its gyration resistance.

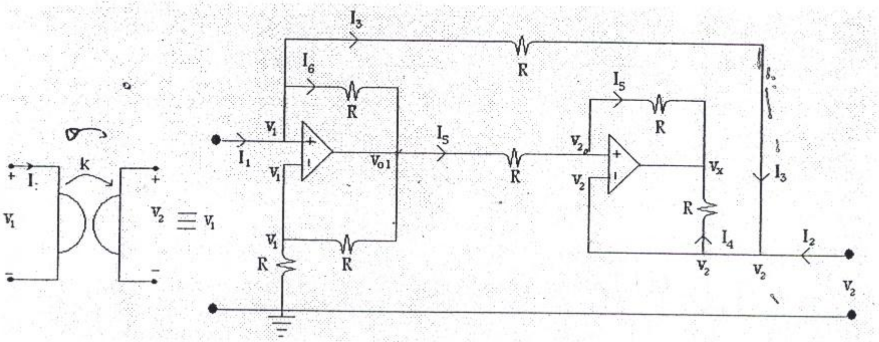


Figure (1)

....

[2] (i)Derive an expression for the input impedance (Z_{in})for the circuit shown in figure (2).
(ii)What does that circuit simulate?
Or (iii) Show that that circuit is equivalent to a **grounded inductor** and find its value.

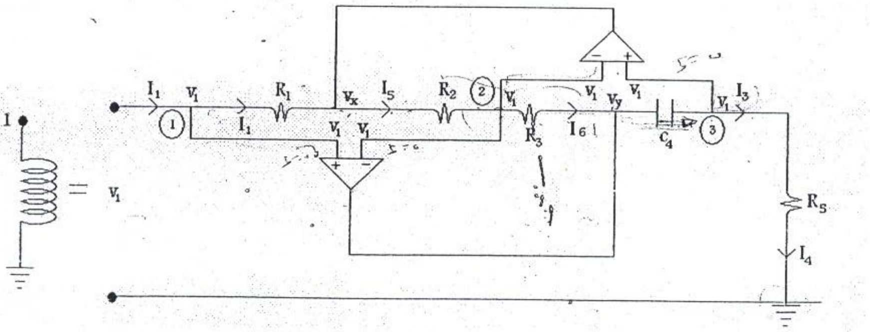


Figure (2)

....

[3]Find the transmission matrix of the **floating inductor** shown in figure (3)

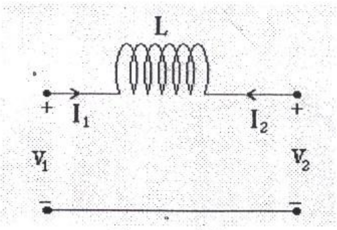


Figure (3)

……………………………………………………………………………………

[4] Derive an expression for the transmission matrix (T) of the Deboo gyrator shown in figure (4)

(ii) Show how it can be used to simulate **a floating inductor**

(iii) How many elements are needed to simulate the floating inductor?

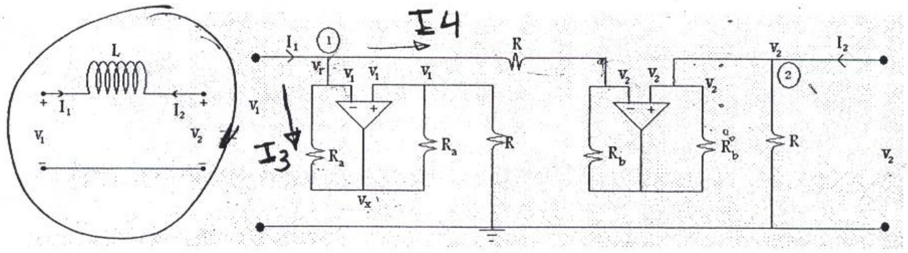


Figure (4)

……………………………………………………………………………………

[5](i)Find the transmission matrix (T) of the **gyrator** shown in figure (5)

(ii) Prove that AD-BC=1 for ideal gyrator

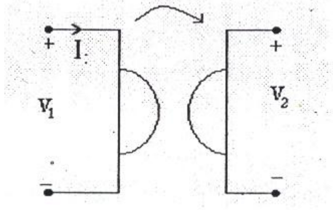


Figure (5)

……………………………………………………………………………………

[6]Find the transmission matrix (T) of the grounded capacitor network shown in figure (6)

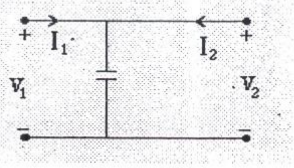


Figure (6)

……………………………………………………………………………………

[7] Prove that the transmission matrix (T) of the circuit shown in figure (7) is equivalent ~~to a grounded inductor~~. What is its value?

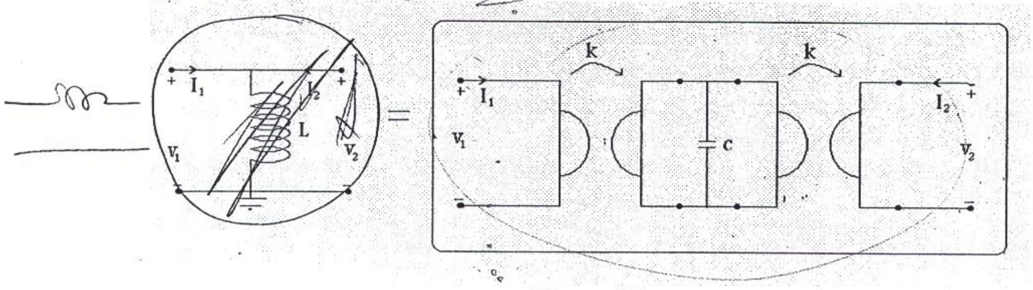


Figure (7)

……………………………………………………………………………………

[8] Prove that the input impedance (Z_{in}) of the network shown in figure (8) simulates an inductor.

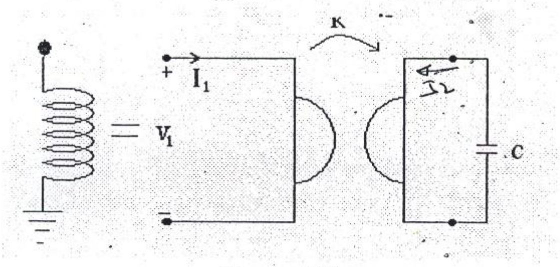


Figure (8)

……………………………………………………………………………………

[9] Assume ideal op amps, find the transmission matrix T and the impedance matrix Z of the gyrator circuit shown in figure (9), hence find the necessary condition that the gyrator be ideal. If a=2 find the value of b for an ideal gyrator.

(ii) Show how to realize a **grounded inductor** L, using this gyrator. Find the design equation for L in terms of circuit parameters..

(iii) Is it possible to realize **a floating inductor** L using two such gyrators? Explain your answer.

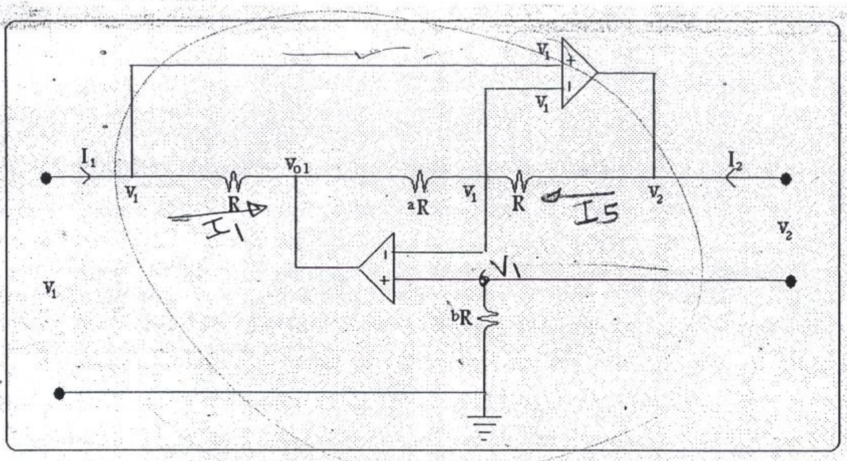


Figure (9)

[10] Find the transmission matrix of the **ground inductor** shown in figure (10).

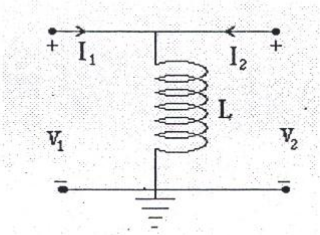


Figure (10)

[11] Find the transmission matrix (T) of the Network shown in figure (11).

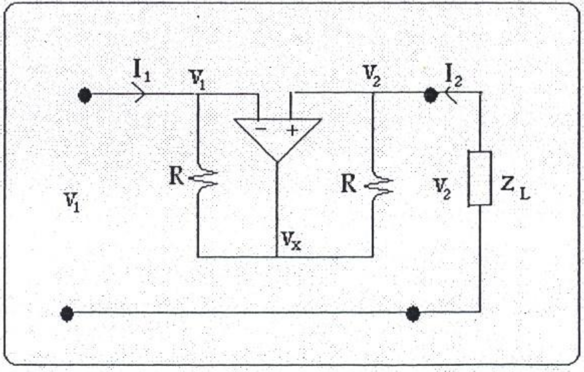
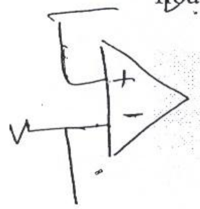


Figure (11)

[12] Show that Riordan gyrator circuit shown in figure (12) realizes a floating **inductor** L, and find its value.



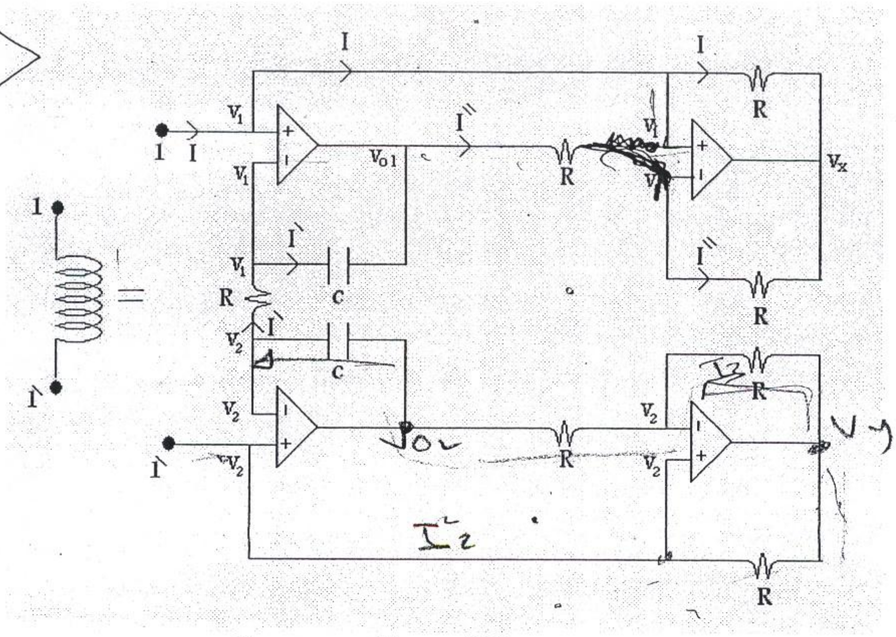


Figure (12)

[13] Show that the circuit shown in figure (13) realizes an inductor and its inductance is 4C

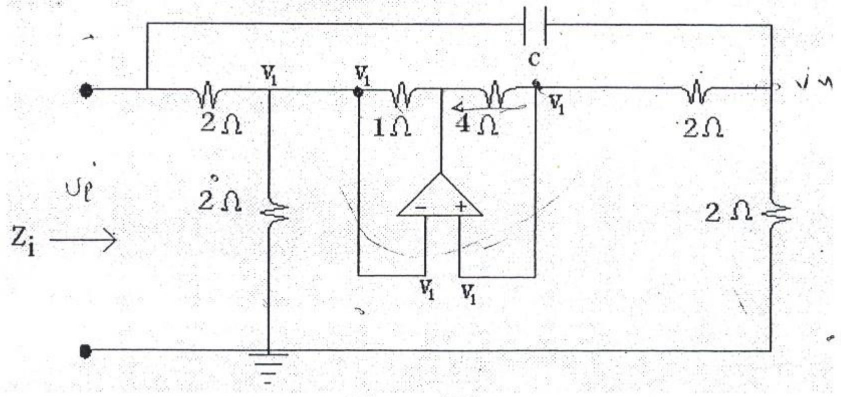


Figure (13)

[14](i)Find an expression for the input impedance of the circuit shown in figure (14).

(ii) Show that it is equivalent to FNDR.

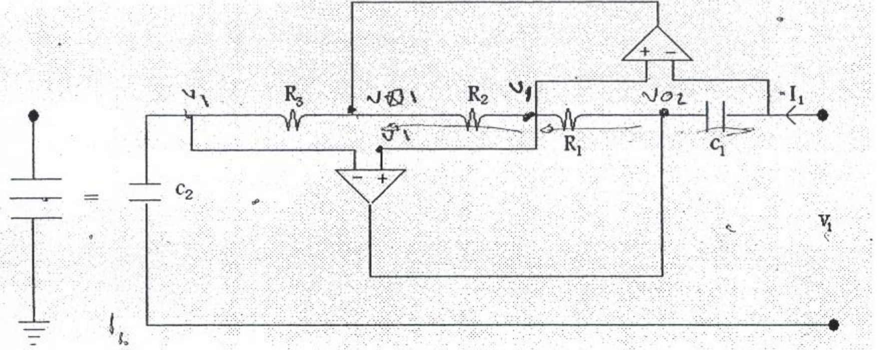


Figure (14)

Sheet ④

-[1]-

[1]- $$* \; I_1 = I_6 + I_3 = \frac{V_1 - V_{o1}}{R} + \frac{V_1 - V_2}{R}$$

$$V_1 = V_{o1} \frac{R}{R+R} \Rightarrow \boxed{V_{o1} = 2V_1}$$

$$\therefore I_1 = \cancel{\frac{V_1 - 2V_1}{R}} \cancel{+ \frac{V_1}{R}} - \frac{V_2}{R}$$

$$\therefore I_1 = -\frac{1}{R} V_2 \Rightarrow \boxed{C = -\frac{1}{R}} \; \boxed{D = 0}$$

$$* \; I_2 = I_4 - I_3 = \frac{V_2 - V_x}{R} - \frac{V_1 - V_2}{R}$$

$$V_{o1} - V_2 = V_2 - V_x$$

$$\therefore 2V_2 = V_{o1} + V_x = 2V_1 + V_x$$

$$\therefore V_x = 2(V_2 - V_1)$$

$$\therefore I_2 = \frac{\cancel{V_2 - 2V_2} + 2V_1 - V_1 \cancel{+ V_2}}{R}$$

$$\therefore I_2 = \frac{V_1}{R} \Rightarrow V_1 = R I_2 \Rightarrow \boxed{A = 0} \; \boxed{B = -R}$$

$$\therefore [T] = \begin{bmatrix} 0 & -R \\ -1/R & 0 \end{bmatrix},$$

[2]-

$$I_1 = \frac{V_1 - V_x}{R_1}, \quad I_5 = \frac{V_x - V_1}{R_2}, \quad I_6 = \frac{V_1 - V_y}{R_3}$$

$$V_x = V_1 - I_1 R_1, \quad I_5 = \frac{V_1 - I_1 R_1 - V_1}{R_2}$$

$$I_5 = -I_1 \frac{R_1}{R_2}$$

$$I_5 = I_6 = \frac{V_1 - V_y}{R_3} = -I_1 \frac{R_1}{R_2}$$

$$V_y = V_1 + I_1 \frac{R_1 R_3}{R_2}$$

$$I_3 = (V_y - V_1) \, S C_4$$

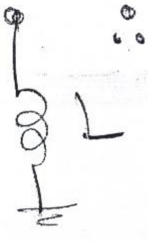
$$I_3 = \left(V_1 + I_1 \frac{R_1 R_3}{R_2} - V_1\right) S C_4$$

$$I_3 = I_1 \frac{S C_4 R_1 R_3}{R_2}$$

$$I_3 = I_4 = \frac{V_1}{R_5}$$

$$\frac{V_1}{R_5} = I_1 \frac{S C_4 R_1 R_3}{R_2}$$

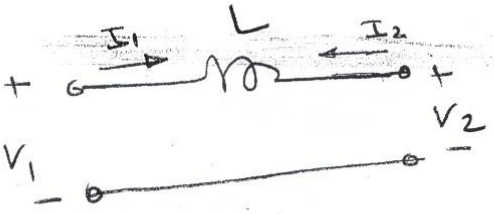
$$\therefore \frac{V_1}{I_1} = Z_{in} = S \frac{C_4 R_1 R_3 R_5}{R_2}$$



∴ the circuit equivalent to grounded Inductor with Inductance

$$L = \frac{C_4 R_1 R_3 R_5}{R_2} \quad \#$$

[3]- $\boxed{T = ??}$



$$I_1 = -I_2 \Longrightarrow C = 0 \ , \ D = 1$$

$$V_1 = LSI_2 + V_2 \Longrightarrow A = 1 \ , \ B = SL$$

$$[T] = \begin{bmatrix} 1 & SL \\ 0 & 1 \end{bmatrix}$$

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[4]-

$$I_1 = I_3 + I_4 = \frac{V_1 - V_x}{R_a} + \frac{V_1 - V_2}{R}$$

$$V_1 = V_x\left(\frac{R}{R_a + R}\right) \Rightarrow V_x = V_1\left(\frac{R_a}{R} + 1\right)$$

$$I_1 = \frac{V_1 - V_1\left(\frac{R_a}{R} + 1\right)}{R_a} + \frac{V_1 - V_2}{R}$$

$$I_1 = -\frac{V_1}{R} + \frac{V_1}{R} - \frac{V_2}{R} = -\frac{V_2}{R}$$

$$\therefore I_1 = -\frac{1}{R}V_2 \Rightarrow \boxed{C = -1/R \ , D = 0}$$

-[4]-

$$I_4 = \frac{V_2 - V_y}{R_b} = \frac{V_1 - V_2}{R}$$

$$\therefore V_2 - V_y = \frac{R_b}{R}(V_1 - V_2)$$

$$V_y = V_2 - \frac{R_b}{R}(V_1 - V_2)$$

$$I_2 = \frac{V_2}{R} + \frac{V_2 - V_y}{R_b}$$

$$I_2 = \frac{V_2}{R} + \frac{V_2 - V_2 + \frac{R_b}{R}(V_1 - V_2)}{R_b}$$

$$I_2 = \frac{V_2}{R} + \frac{V_1}{R} - \frac{V_2}{R} = \frac{V_1}{R}$$

$$\boxed{V_1 = R I_2} \Longrightarrow \boxed{A = 0, \; B = -R}$$

$$[T] = \begin{bmatrix} 0 & -R \\ -1/R & 0 \end{bmatrix}$$

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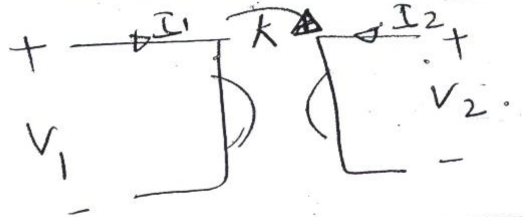
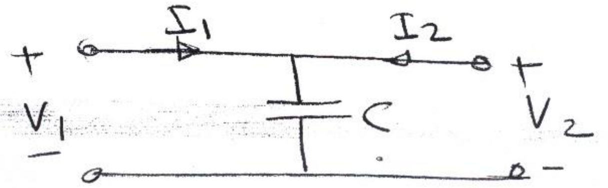
[5]-



$$[T] = \begin{bmatrix} 0 & K \\ 1/K & 0 \end{bmatrix} \Longrightarrow \boxed{AD - CB = -1}$$

[6]- -[5]-



$$V_1 = V_2$$

$$V_2 = (I_1 + I_2)\frac{1}{sC}$$

$$\therefore\ I_1 = sC\,V_2 - I_2$$

$$[T] = \begin{bmatrix} 1 & 0 \\ sC & -1 \end{bmatrix}$$

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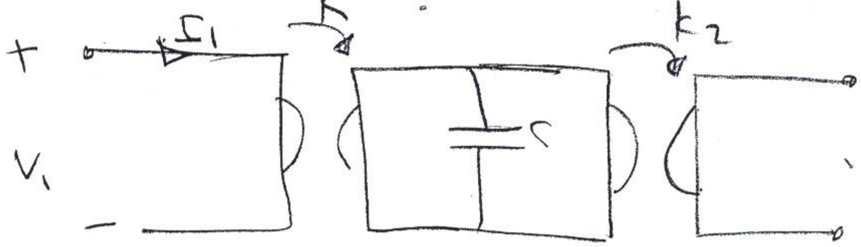
[7]-

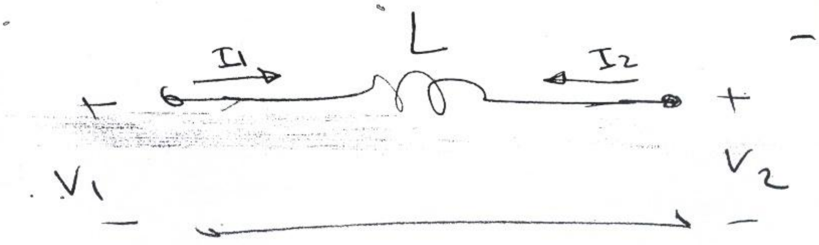


$$[T] = \begin{bmatrix} 0 & k \\ 1/k & 0 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ sC & 1 \end{bmatrix}\begin{bmatrix} 0 & k \\ 1/k & 0 \end{bmatrix}$$

$$= \begin{bmatrix} sCk & k \\ 1/k & 0 \end{bmatrix}\begin{bmatrix} 0 & k \\ 1/k & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & sCk^2 \\ 0 & 1 \end{bmatrix} \Rightarrow \boxed{L = Ck^2}$$

$-\boxed{6}-$



$\therefore$ the circuit is equivalent to Floating Inductor.

with $\boxed{L = CK^2}$

[illegible]

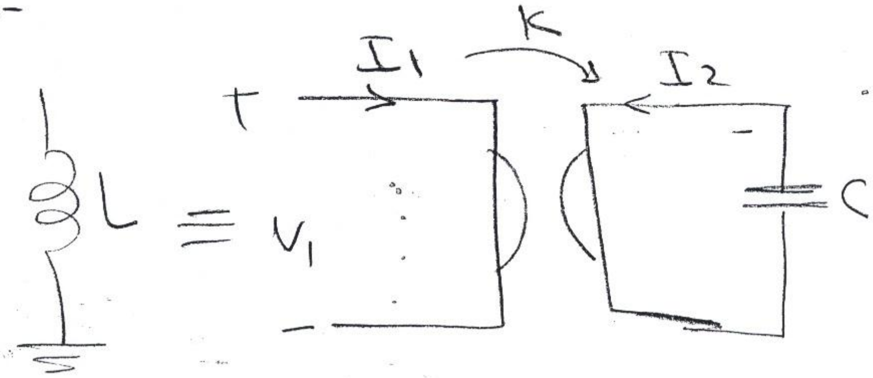
$(I_1 - I_2)$ $V_1 = I_1 SL + V_2$

$I_1 = -I_2$

$V_1 = -I_2 SL + V_2$

$T = \begin{bmatrix} 1 & SL \\ 0 & 1 \end{bmatrix}$

$\boxed{8}$-



$V_1 = -KI_2 \quad , V_2 = KI_1$

$V_2 = -\frac{I_2}{SC}$

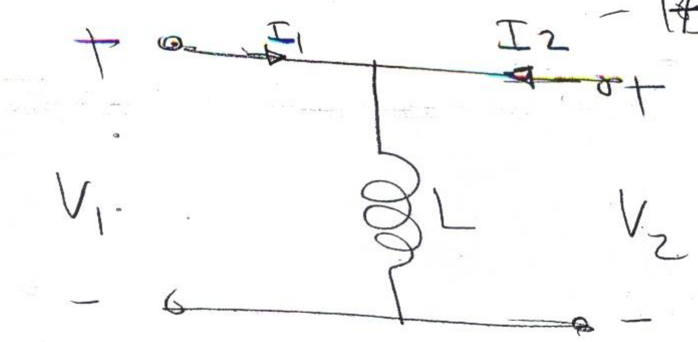
$\therefore \quad -\frac{I_2}{SC} = KI_1 \Rightarrow \boxed{I_2 = -SKCI}$

$\therefore V_1 = SK^2C\,I_1.$

$Z_{in} = \frac{V_1}{I_1} = SK^2C \Rightarrow \boxed{L = K^2C}$

[10]-

[7]-



$V_1 = V_2 \Rightarrow A = 1 , B = 0$

$V_2 = (I_1 + I_2) SL \Rightarrow$

$I_1 = \frac{V_2}{SL} - I_2 \Rightarrow C = \frac{1}{SL} , D = 1$

$$[T] = \begin{bmatrix} 1 & 0 \\ \frac{1}{SL} & 1 \end{bmatrix}$$

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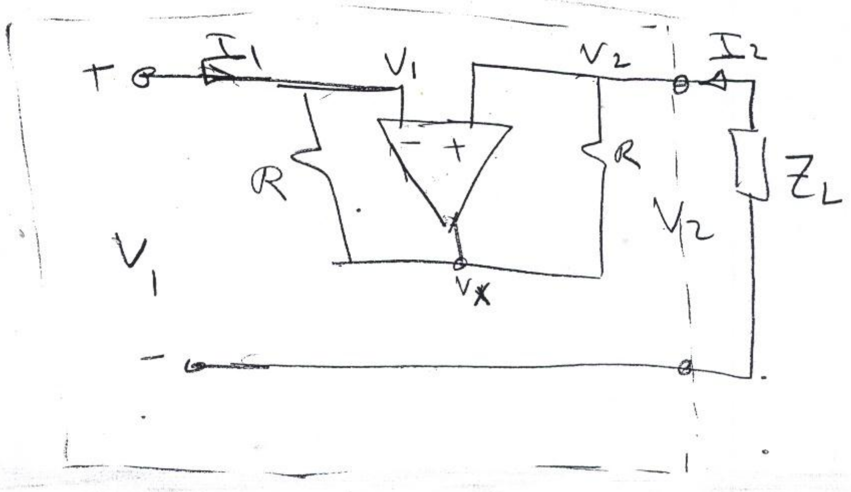
[11]-

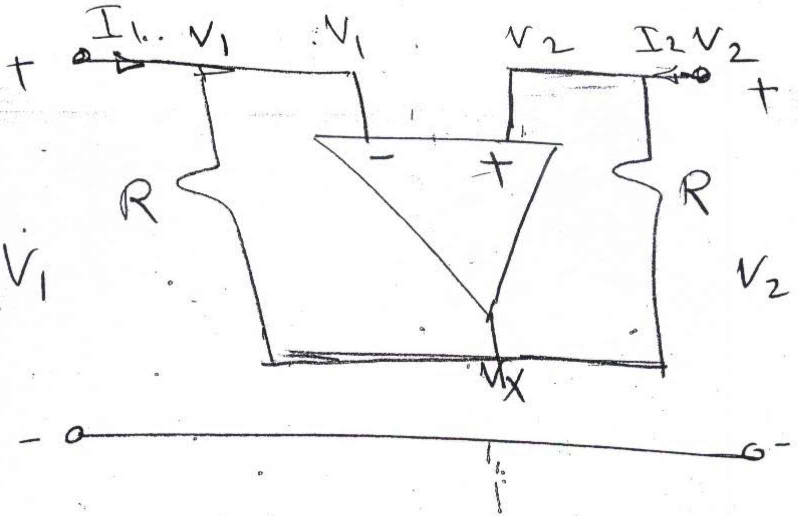
Find

[T]



network

(8)-



$$V_1 = V_2 \Rightarrow A = 1 , B = 0$$

$$I_1 = \frac{V_1 - V_x}{R} , \quad I_2 = \frac{V_2 - V_x}{R}$$

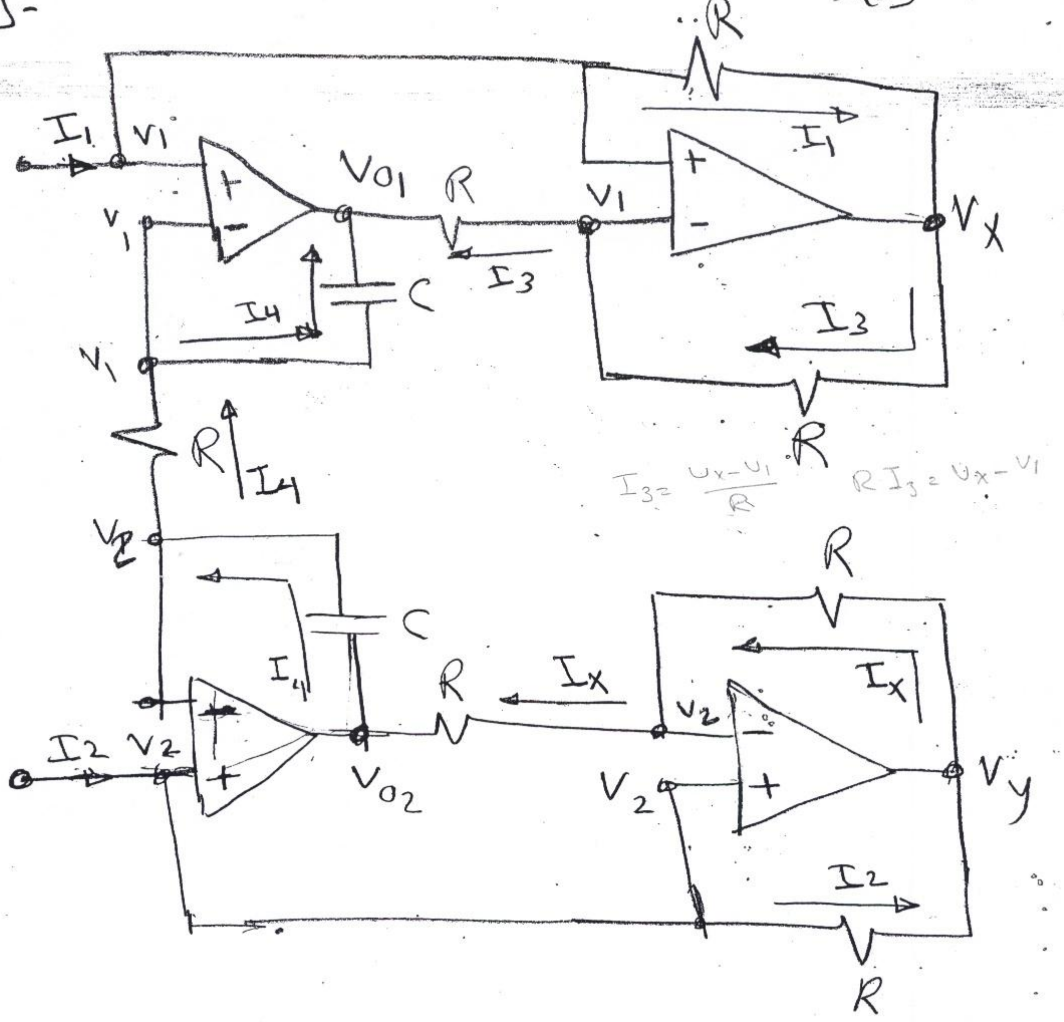
$$\boxed{V_1 = V_2}$$

$$I_1 = I_2 \Rightarrow C = 0 \quad D = -1$$

$$[T] = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

[12]-

-[8]-



$$I_1 = \frac{V_1 - V_x}{R} \quad , \quad V_x = I_3 R + V_1$$

$$\therefore I_1 = \frac{\cancel{V_1} - \cancel{V_1} - I_3 R}{R} = -I_3$$

$$\boxed{I_1 = -I_3}$$

$$I_3 = \frac{V_1 - V_{o1}}{R} = -I_1$$

$$I_1 = \frac{V_{o1} - V_1}{R}$$

$$V_{o1} = V_1 - \frac{I_4}{SC}$$

$$I_1 = \frac{\cancel{V_1} - \frac{I_4}{SC} - \cancel{V_1}}{R} = \frac{-I_4}{SCR}$$

$$\therefore \boxed{I_4 = -I_1 SCR}$$

$$I_4 = \frac{V_2 - V_1}{R} = -I_1 SCR$$

$$\boxed{\therefore \quad I_1 = \frac{V_1 - V_2}{SCR^2}} \longrightarrow ①$$

$$V_{o2} = \frac{I_4}{SC} + V_2$$

$$V_{o2} = \frac{-I_1 \cancel{SC} R}{\cancel{SC}} + V_2$$

$$\boxed{V_{o2} = V_2 - R I_1} \longrightarrow ②$$

$$I_2 = \frac{V_2 - V_y}{R}, \quad V_y = I_x R + V_2$$

$$\therefore I_2 = \frac{V_2 - I_x R - V_2}{R}$$

$$\boxed{I_2 = -I_x}$$

$$V_2 = R I_x + V_{o2}$$

$$\boxed{\therefore V_{o2} = V_2 + R I_2} \longrightarrow ③$$

From ② ، ③

$$\therefore \cancel{V_2} + I_2 R = \cancel{V_2} - R I_1$$

$$④ \longleftarrow \therefore \boxed{I_1 = -I_2} \Rightarrow \boxed{C = 0 \quad , D = 1}$$

From ① ، ④

$$-I_2 = \frac{V_1 - V_2}{SCR^2}$$

$$\boxed{\therefore V_1 = V_2 - I_2 SCR^2}$$

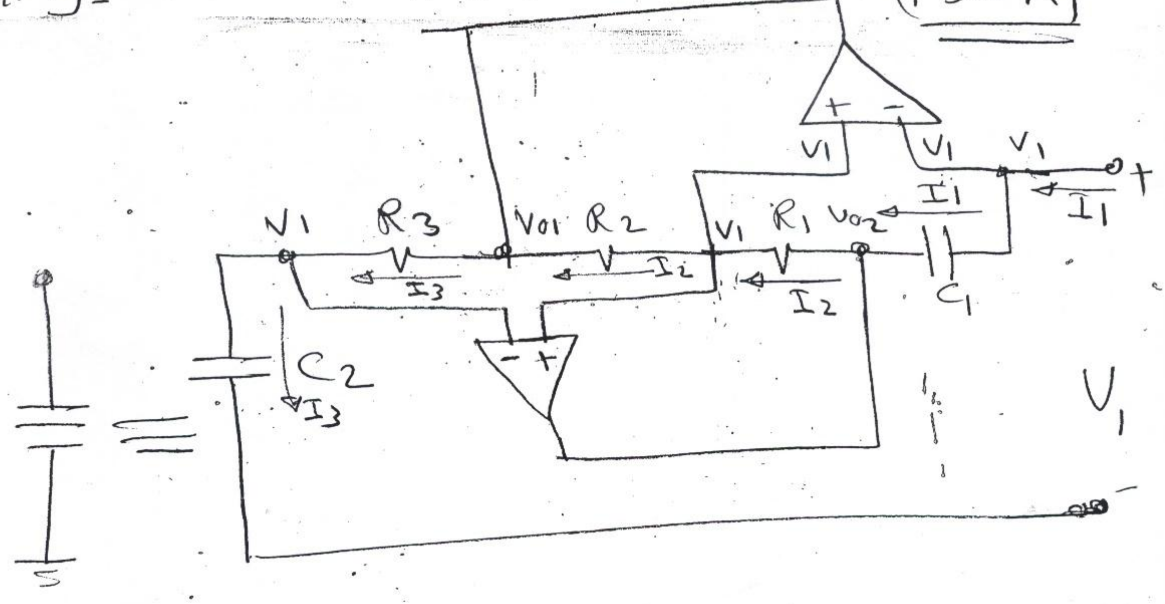
$$\therefore \boxed{A = 1 \quad , B = SCR^2}$$

$$\therefore [T] = \begin{bmatrix} 1 & SCR^2 \\ 0 & 1 \end{bmatrix}$$

∴ the Circuit of Riordan gyrater is Realizes a floating Inductor

$$\boxed{L = CR^2}$$

[14] (12) * Frequency Dependent negative Resistan (FDNR)



$$V_1 = \frac{I_1}{sC} + V_{o2}$$

$$V_{o2} = I_2R_1 + V_1$$

$$\therefore \cancel{V_1} = \frac{I_1}{sC} + I_2R_1 + \cancel{V_1}$$

$$\therefore \boxed{I_2 = -\frac{1}{sCR_1} I_1}$$

$$V_1 = I_2R_2 + V_{o1}$$

$$V_{o1} = I_3R_3 + V_1$$

$$\therefore \cancel{V_1} = I_2R_2 + I_3R_3 + \cancel{V_1}$$

$$\therefore \boxed{I_2 = -\frac{R_3}{R_2} I_3}$$

$$\therefore -\frac{R_3}{R_2} I_3 = -\frac{1}{sCR_1} I_1$$

(3) -

$$\boxed{I_3 = \frac{R_2}{s C_1 R_1 R_3} I_1}$$

$$V_1 = \frac{I_3}{s C_2}$$

$$V_1 = \frac{R_2}{s^2 C_1 C_2 R_1 R_3} \cdot I_1$$

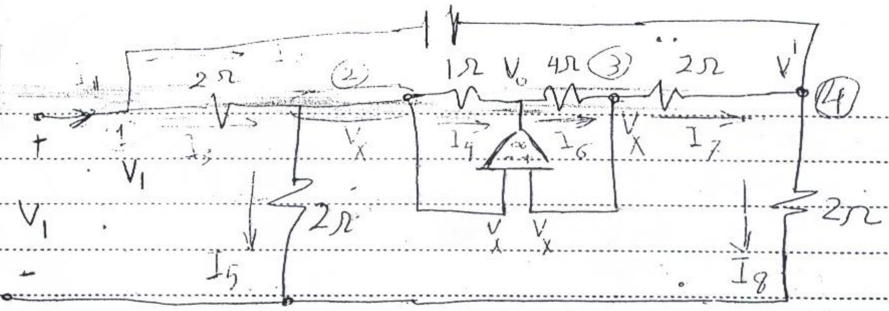
$$\therefore Z_{in} = \frac{V_1}{I_1} = \frac{R_2}{s^2 C_1 C_2 R_1 R_3}$$

$$\boxed{Z_{in} = \frac{R_2}{-w^2 C_1 C_2 R_1 R_3}}$$

it is equivalent

FDNR

[13]



①

Apply KCL at node 1, we get

$$I_1 = I_2 + I_3 = \frac{V_1 - V'}{\frac{1}{sC}} + \frac{V_1 - V_X}{2} = V_1 sC - V' sC + \frac{V_1}{2}$$

$$= V_1\left(\frac{1}{2} + sC\right) - \frac{V_X}{2} - V' sC \text{ —— } 1$$

Apply KCL at node 2, we obtain

$$I_3 = I_4 + I_5 = \frac{V_X}{2} + \frac{V_X - V_o}{1} = \frac{3}{2} V_X - V_o \text{ —— }$$

Apply KCL at node 3, we get

$$I_6 = I_7$$

$$\frac{V_o - V_X}{4} = \frac{V_X - V'}{2}$$

$$\frac{V_o}{4} - \frac{V_X}{4} = \frac{V_X}{2} - \frac{V'}{2}$$

$$\frac{3}{4} V_X = \frac{V_o}{4} + \frac{V'}{2}$$

$$\therefore V_o = 3V_X - 2V' \text{ —— } 3$$

Substitute V_o from ③ into ②, we obtain

$$I_3 = \frac{3}{2} V_X - \left[3V_X - 2V'\right]$$

$$= 2V' - \frac{3}{2} V_X .$$

$$\text{but } I_3 = \frac{V_1 - V_X}{2}$$

$$\frac{V_1 - V_X}{2} = 2V' - \frac{3}{2} V_X$$

$$V_1 \quad V_X = 2V' - 3 V_X$$

$$\frac{V_1}{2} = 2V' - V_X$$

$$V_1 = 4V' - 2V_X \text{ —— } ④$$

Apply KCL at Node 4, we get

$$I_3 + I_7 = I_8$$

$$\frac{V_1 - V'}{\frac{1}{sC}} + \frac{V_X - V'}{2} = \frac{V'}{2}$$

$$V_1 sC - V' sC + \frac{V_X}{2} - \frac{V'}{2} = \frac{V'}{2}$$

$$V_1 sC = V'(1 + sC) - \frac{V_X}{2}$$

$$V_1 = V'\left(\frac{1}{sC} + 1\right) - \frac{1}{2sC} V_X \quad ⑤$$

substitute ④ V_1 into 5, we get

$$4V' - 2V_X = \frac{V'}{sC} + V' - \frac{1}{2sC} V_X$$

$$2V_X - \frac{1}{2sC} V_X = 3V' - \frac{1}{sC} V'$$

$$4sC\, V_X - V_X = 6sC V' - 2V'$$

$$V_X (4sC - 1) = V'(6sC - 2)$$

$$V' = V_X \frac{4sC - 1}{6sC - 2} \text{ —— } ⑥$$

substitute V' from 6 into 4, we get

$$V_1 = 4V_X\left(\frac{4sC-1}{6sC-2}\right) - 2V_X$$

$$= V_X\left(\frac{16sC-4}{6sC-2} - 2\right) = V_X\left(\frac{16sC-4-12s}{6sC-2}\right)$$

$$V_1 = V_X \frac{4sC}{6sC-2} \Rightarrow V_X = V_1\left(\frac{6sC-2}{4sC}\right)$$

substitute V_x from ⑦ and V' from ⑥ into 1, we ge

③ $$I_1 = V_1\left(\frac{1}{2}+sc\right) - \frac{V_1}{2}\left[\frac{3}{2}-\frac{2}{4sc}\right] - scV_1\left[\frac{3}{2}-\frac{2}{4sc}\right]\left[\frac{4sc}{6sc}\right.$$

$$= V_1\left(\frac{1}{2}+sc\right) - V_1\left(\frac{3}{4}-\frac{1}{4sc}\right) - V_1\left(\frac{3sc}{2}-\frac{1}{2}\right)\left(\frac{4sc}{6sc}\right.$$

$$= V_1\left\{\left[\frac{1}{2}+sc-\frac{3}{4}+\frac{1}{4sc}\right] - \left[\frac{(3sc-1)(4sc-1)}{12sc-4}\right]\right.$$

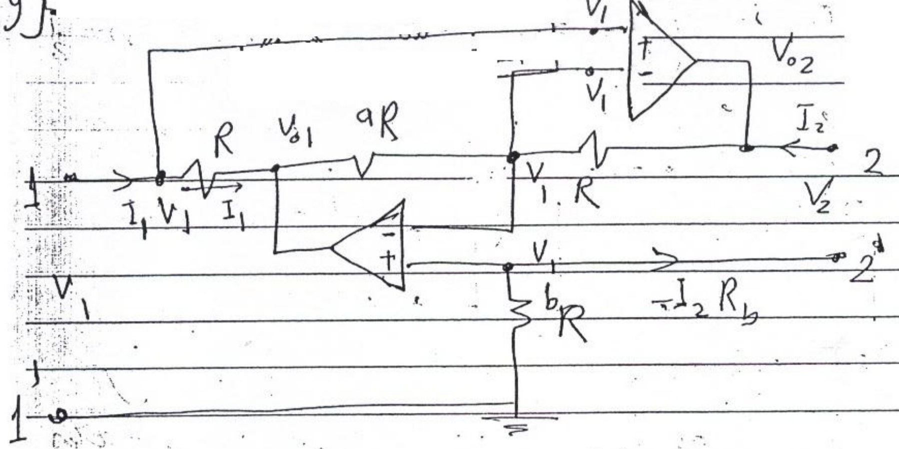
$$= V_1\left\{-\frac{1}{4}+sc+\frac{1}{4sc}\right] - \left[\frac{\cancel{(3sc-1)}(4sc-1)}{4\cancel{(3sc-1)}}\right]\Bigg\}$$

$$= V_1\left\{\cancel{-\frac{1}{4}}\cancel{+sc}+\frac{1}{4sc}\cancel{-sc}\cancel{+\frac{1}{4}}\right\}$$

$$Z_{in} = \frac{V_1}{I_1} = 4sc = sL$$

when $L = 4c$

[9]



$V_1 = V_{o1} + I_1 R$ $\qquad$ $V_1 - V_{o1} = I_1 R$ —— ②

$$\frac{V_{o1} - V_1}{aR} = -\frac{V_2}{R} \quad \text{——} ①$$

$$\boxed{\begin{aligned} V_1 &= AV_2 - BI_2 \\ I_1 &= CV_2 - DI_2 \end{aligned}}$$

$I_1 = V_2$

$V_1 = -I_2 R_b$ —— 1''

~~substitute ② into ①, we get~~

$$\frac{-I_1 \cancel{R}}{a \cancel{R}} = \frac{V_2}{R}$$

$V_{o2} = V_2 - I_2$

$$I_1 = +V_2 \frac{a}{R} \quad \text{——} 2''$$

~~Compare 2', 2'', we get:~~ $C = \frac{a}{R}$ $\quad D = 0$

~~Compare 1', 1'', we get:~~ $A = 0$ $\quad B = R_b$

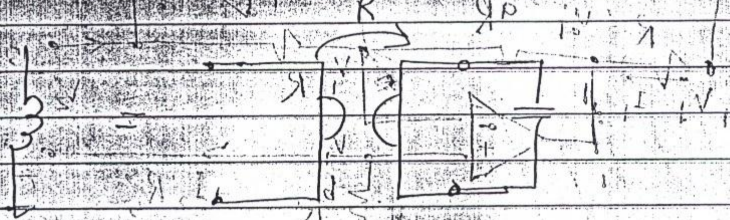
$T = \begin{bmatrix} 0 & R_b \\ a & \end{bmatrix}$ $\qquad$ $\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = \begin{bmatrix} 0 & R_b \\ \frac{a}{R} & 0 \end{bmatrix} \begin{pmatrix} V_2 \\ -I_2 \end{pmatrix}$

The necessary condition that the gyrator be ideal

$AD - BC = 1$

$a = 2 \quad , \quad b = ?$

(ii) $(0)(0) - \left(\frac{a}{R}\right)(bR) = -1$ thus $b = \frac{1}{2}$



we can realize a grounded inductor using this gyrator by terminating it with a capacitor

$L = R^2 C$

(iii) yes it is possible to realize a floating inductor by using two such gyrators as shown in fig: ( )